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Technology for Productivity

ENI Products

MWH-5
Automatic Matching Impedance Network
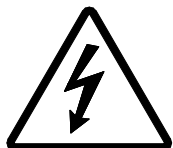
HIGH RF VOLTAGES MAY BE PRESENT AT THE OUTPUT OF THIS UNIT. All operating personnel should use extreme caution in handling these voltages and be thoroughly familiar with this manual.

DO NOT USE ANY CFC (CHLOROFLUOROCARBON) SOLVENT IN THE MAINTENANCE OF THIS PRODUCT. In recognition of our responsibility to protect the environment, this product has been manufactured without the use of CFC's. The no-clean flux now used in all soldering operations may leave a small inert residue that will not affect the performance of the product. The use of CFC's for cleaning or maintenance may result in partial liquification of the no-clean flux residue, which will damage the unit and void the warranty.

QUALITY **ISO 9001** SYSTEM

This product is manufactured at an MKS Instruments' ISO-9001:2000-Quality-System-compliant facility.

Notice

Warranty

ENI warrants to the original purchaser for a period of one year from the date of delivery, each instrument to be free from defects in materials and workmanship. For a period of one year, ENI will, at its option, adjust, repair, or replace defective parts, without charge to the original purchaser, so that the instrument performs according to its specifications.

When warranty service is required, the instrument must be returned, transportation prepaid, to the factory or to one of ENI's designated service centers. If, in our opinion, the instrument has been damaged by accident, unreasonable use, buyer-supplied software or interfacing, improper site preparation or maintenance, or abnormal conditions of operation, repairs will be billed at standard rates. In this case, an estimate will be submitted before the work is started.

THIS LIMITED WARRANTY IS EXCLUSIVE AND ENI MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, AND ALL OTHER EXPRESS ORAL OR WRITTEN WARRANTIES AND ALL WARRANTIES IMPLIED BY LAW, INCLUDING ANY WARRANTIES OF <u>MERCHANTABILITY</u> OR FITNESS FOR A PARTICULAR PURPOSE OR OTHER WARRANTY OF QUALITY ARE <u>EXCLUDED</u> AND DISCLAIMED. IN NO EVENT SHALL ENI BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM BREACH OF ANY WARRANTY, WHETHER EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR FROM ANY CAUSE WHATSOEVER, INCLUDING NEGLIGENCE. Buyer's sole and exclusive remedy under this warranty shall be repair or replacement as set forth above, or if ENI is unable to repair or replace the defective part within a reasonable time, a refund of the price of the part or goods which give rise to the warranty claim.

Service And Technical Assistance

For Service or Repair contact the closest Customer Service Department with the following information:
- Model and serial number
- Purchase order number
- Detailed description of malfunction
- Your company's "Bill To" and "Ship To" address

You will receive a RMA (Return Materials Authorization) number, the warranty status of the unit to be returned and estimated repair charge, if any. The RMA number is your authorization number. Please type this number on your purchase order and shipping label. After ENI receives the unit, a firm quote and estimated date of completion will be given.

For Technical Assistance for your particular application, contact the nearest ENI Sales and Service Center. The following information will help us provide you with prompt and efficient service:
- All of the information contained on the unit's name plate.
- Names and telephone numbers of important contacts.
- Detailed description (i.e. physical damage and/or performance anomalies, quantitative and/or qualitative deviation from specifications), including miscellaneous symptoms, dates and times.
- The environment and circumstances under which the issue developed.
- Supporting test data and/or records that can be provided.
- Any previous, related conversations and/or correspondence with ENI.

Sales & Service Locations

ROCHESTER, NY	ENI Technology, Inc. 100 Highpower Road Rochester, NY 14623	Tel: (585) 292-7440 Fax: (585) 427-7839 Svc: (585) 292-7478
	Toll Free USA Sales Hotline: **Toll Free USA Service** **Hotline:**	**1-800-267-5362** **1-800-724-ENI1 (3641)**
FREMONT, CA **(Service only)**	48834 Kato Road, Suite 110A Fremont, CA 94538	Tel: (510) 353-4ENI (4364) Fax: (510) 353-4360
SAN JOSE, CA **(Sales only)**	MKS Instruments, Inc. 70 Rio Robles San Jose, CA 95134	Tel: (408) 750-0300 Fax: (408) 428-0390
AUSTIN, TX	MKS Instruments, Inc. 1321 Rutherford Lane Suite 200 Austin, TX 78753	Tel: (512) 719-8000 Fax: (512) 719-8095
UNITED KINGDOM	Highway House Norreys Drive Maidenhead Berks, SL6 4BN United Kingdom	Tel: 44-1628-775911 Fax: 44-1628-775902
GERMANY	Sielminger Str. 63 D-70771 Leinfelden- Echterdingen (Stetten) Stuttgart, Germany	Tel: 49-711-947700 Fax: 49-711-9477025
JAPAN	1-21-15 Aoyogi Kunitachi Tokyo 186-0013 Japan	Tel: 81-42-522-9011 Fax: 81-42-522-2636
TAIWAN	No. 49-1, Lane 2, Sect. 2 Kuang Fu Rd. Hsinchu 300, Taiwan Republic of China	Tel: 886-3-575-1199 Fax: 886-3-575-1022

Product and Applications information also available on the Internet at:

http://www.mksinst.com

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PRODUCT MANUAL REVISION CONTROL FORM

Title:	MWH-5-01	Part #:	1016-001	Final Assy #:	MWH-5-01
	Operation Manual	Rev #:	B	Eff. Date:	03/30/05

CONTENTS	DESCRIPTION	REV LEVEL
BOARD LAYOUTS		
SCHEMATICS		
010-1016-950	MOUNTING & OUTLINE, MWH-5-01	A
1014-600	INTERCONN DIAG, MWH-5-01 TUNER	A
PARTS LIST		

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Introduction

The MATCHWORK®-5D-01 (MWH-5-01) is an automatic impedance matching network specifically designed to interface ENI 13.56MHz RF generators to gas plasma reactor chambers.

The MWH-5-01 is capable of handling up to 5000VA of continuous RF power and is able to match an extremely wide range of load impedances.

The MWH-5-01 consists of two separate assemblies: a Tuner unit and a Controller unit. The Tuner unit contains the matching network whose output impedance is varied by two motor controlled capacitors and a fixed inductor. The Controller unit drives the tuner motors in response to signals on the Remote Interface or RF sensors in the Tuner unit. The MWH-5-01 uses a microprocessor based control circuit for improved accuracy and tuning precision.

The MWH-5-01 may be operated as an automatic device where no external control is required. This is called the Automatic Control Mode. Conversely, the system can be fully controlled by the user with analog and digital signals through the Remote Interface port on the Controller unit. This is called the User Control mode. When using a computer or terminal in the User Control mode, the user has complete access to MWH-5-01 functions through the use of simple ASCII based commands over a standard serial link.

The following diagram outlines each assembly's function.
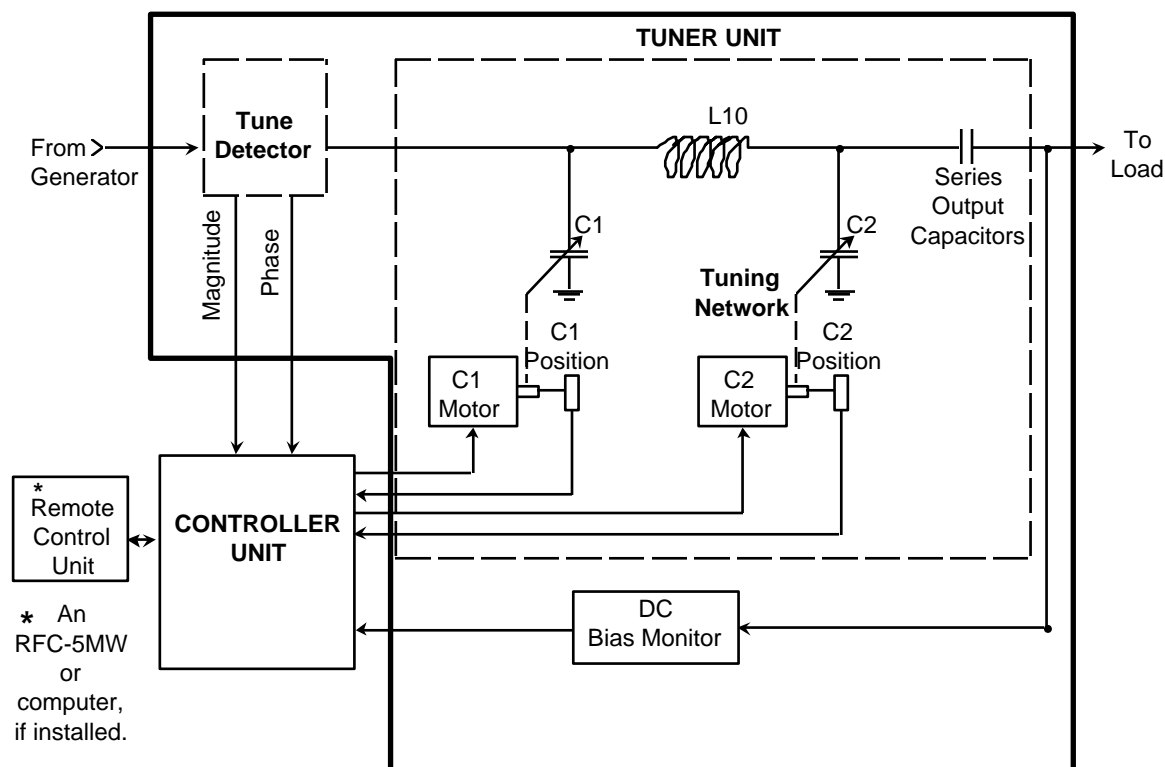
MWH-5-01 Overall Block Diagram

This manual is divided into three chapters and appendices. Please refer to the following descriptions to help you locate the information you'll need to understand this system's capabilities.

Chapter	
1	Deals with precautionary details. Please read this section if you are unfamiliar with the MWH-5-01 or ENI's warranty procedures.
2	Tells you how to install and power up the system for the first time.
3	Describes operational details of the MWH-5-01.
Appendix A	
A.1	Technical Specifications
A.2	Controller and Tuner Connectors
A.3	DIP Switches
A.4	RF Alignment
A.5	MWH-5-01 Calibration

Chapter 1

Safety

1.1   *Labels*

Labels are provided to alert operating and service personnel to conditions that may cause personal injury or damage to the equipment from misuse or abuse. Please read the labels and understand their meaning.

1.1.1   Important Operating or Maintenance Cautions

The caution label is used in this manual to advise the reader of important operating or maintenance procedures that must be carefully followed to maintain equipment reliability.

1.1.2   Shock Hazard Warnings

The warning label is used in this manual to warn the reader of a procedure or practice that could result in personal injury if not followed carefully.

1.1.3   Service
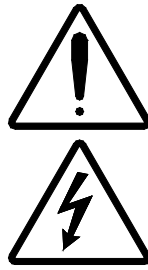
ENI is responsible for safety, reliability, and performance of the equipment only if:

- *Assembly operations, extensions, readjustments, modifications, or repairs are carried out by authorized personnel.*

- *The electrical installation is made in accordance with the installation instructions provided and the room in which the equipment is installed complies with the environmental requirements.*

- *The equipment is used in accordance with the instructions for use.*

1.1.3.1 Periodic Maintenance

The MWH-5-01 MATCHWORK® contains a wire mesh air intake filter. When operated in normally dusty environments, this filter will collect dust, which will lead to reduced airflow. This filter must be cleaned periodically to maintain adequate cooling airflow through the unit. It is recommended that this filter be inspected monthly for accumulated dust, and cleaned if necessary. If the operating environment is exceptionally clean, the periodic inspection and cleaning intervals can be extended, as experience shows appropriate.

To clean the air filter:
1. Shut off MATCHWORK® power to stop the fan from spinning.
2. Using a portable vacuum cleaner, suck the dust from the fan surface in the direction opposite normal airflow.
3. Restore MATCHWORK® prime power and make sure the fan is operational.
4. Alternately, the fan filter can be removed and cleaned with a soft brush, rinsed in water, dried, and reinstalled.

For best reliability, it is recommended that the MATCHWORK® not be operated without the air filter in place. Doing so will allow airborne contamination to enter the MATCHWORK® and collect on high voltage components inside. In extreme cases, this will lead to catastrophic failure of the network.

1.1.4 Name Plate

The MWH-5-01 can be identified by a name plate at the rear of the unit and contains the following information.

```
A ─────────────► ENI
B ──►  MODEL:
C ──►  SERIAL NO:
F ──►  DATE: MM/DD/YY    REV: X ◄── D
E ──►  CUST NO: _____
```
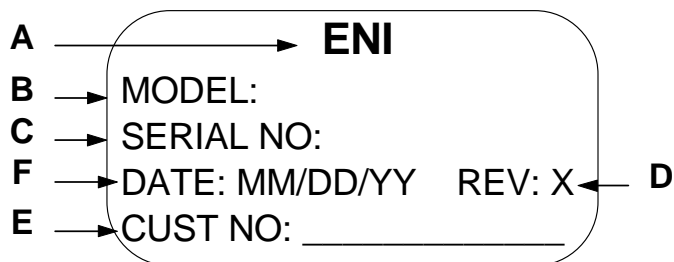
MWH-5-01 Serial Tag
Figure 1.1.4

A. **Manufacturer:**
ENI
Rochester, NY USA

B. **Model:**
The assembly number that uniquely identifies product configuration is contained on this line.

C. **Serial #:**
This line contains a number that is sequentially assigned as the product is manufactured.

D. **Revision:**
The revision letter identifying product configuration is contained on this line. Revision A is the initial revision level.

E. This line contains customer assigned identification number.

F. **Date:**
Proper identification of the date of manufacture is contained on this line.

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Chapter 2

System Installation

2.1 Initial Inspection

2.1.1 Mechanical Inspection

If damage to the shipping carton is evident, request the carrier's agent be present when the unit is unpacked. Check for equipment damage and inspect the cabinet and panels for dents and scratches.

2.1.2 Claim for Damage

Please notify ENI directly or your authorized ENI representative if the MWH-5-01 is mechanically damaged or fails to meet specifications upon receipt. Retain our shipping carton and packing material for the carrier's inspection, as well as for subsequent use to return the unit should this become necessary.

2.1.3 Packaging for Reshipment

Whenever possible, the original shipping carton and packing material should be used for reshipment. If the original packing material is not available, wrap the instrument in heavy paper or plastic. Use a strong shipping container. If a cardboard carton is used, it should be at least 200 lbs. test material.

Use shock-absorbing material around all sides of the instrument to provide a firm cushion and to prevent movement inside the container wall on each side. Protect the front panel by means of cardboard spacers inserted between the front panel and the shipping carton. Make sure that the instrument cannot move in the container during shipping. Seal the carton with a good grade of shipping tape and mark the container:

FRAGILE! ELECTRONIC INSTRUMENT

2.2   Installation Requirements

The Mounting & Outline Drawing in the rear of this manual shows the overall dimensions of the MWH-5 in both English and Metric measurements.

2.2.1   Bench Operation

The MW Controller unit is contained in a small metal box. The Tuner/Controller combination can be used on a bench as long as the cooling and ventilation requirements are met.

2.2.2   Cooling and Ventilation

The MWH-5-01 must be mounted in an environment that allows adequate airflow and has an ambient temperature within the range listed in the specifications. A minimum clearance of three inches between the unit air intake/exhausts and obstructing surfaces should be maintained. The following diagram shows the preferred mounting method with minimum recommended spacing between the Tuner and obstructing walls.
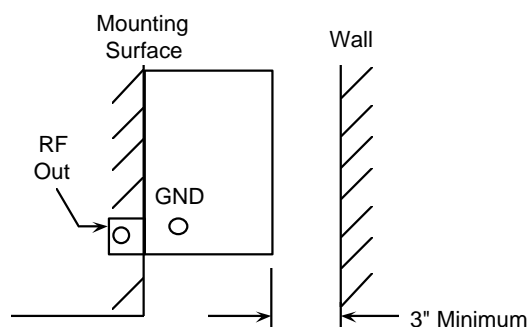
Preferred Mounting Method
Figure 2.2.2

2.2.3   Power

The MWH-5-01 is designed to take its power from the local system. The unit requires a single +24VDC (nominal) power supply. For best performance the supply should be within ±10%. The power source must also be able to provide a minimum of 2 Amps continuous (4 Amps peak) current.

The MATCHWORK$^®$ and Controller are a calibrated and matched pair, as indicated by the Serial Number. Do not mix different MATCHWORK$^®$s and Controllers as severe damage may occur.

2.3 System Setup

The following diagram shows how to interconnect an RF delivery system which includes the MWH-5-01 Matching Network and RFC-5MW Remote Controller.
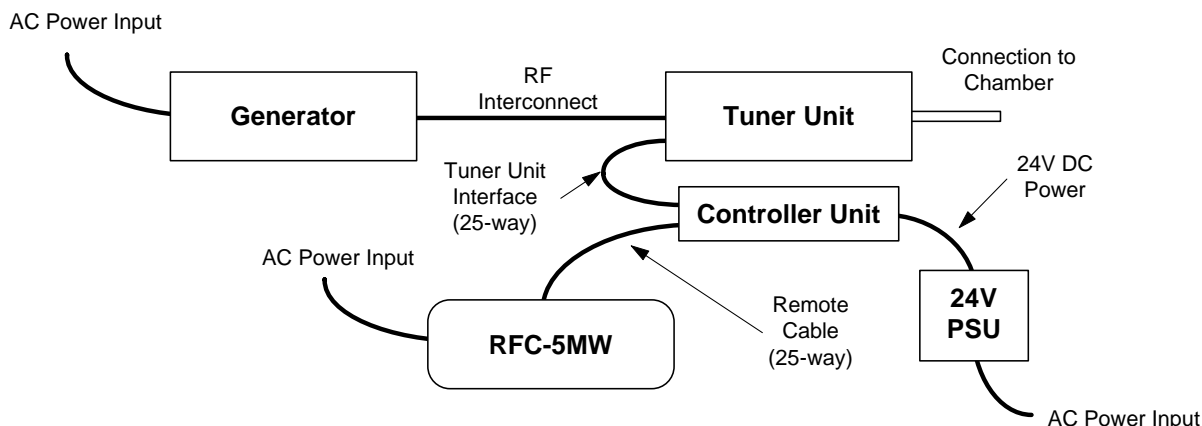
System Interconnect Diagram
Figure 2.3

2.3.1 RF Power Connections

The MWH-5-01 should be located as near to the plasma chamber as possible. Connection to the chamber is made via the RF OUTPUT on the Tuner unit. The best way to make this connection is with a short copper strap approximately 1 inch wide and 1/16 inch thick.

Connection to the generator is made via a cable from the generator to the RF INPUT 'N' connector on the Tuner unit. A minimal length of RG-393/U or equivalent coaxial cable should be used.

Never *make any RF connections with power applied to the generator.*

2.3.2   Controller Connections

The Controller unit has three ports that are used for system setup:

- POWER INPUT
- TUNER UNIT INTERFACE
- REMOTE INTERFACE

Never *make any connections to the Controller unit with power applied to the MWH-5-01. Damage may occur to the unit if connections are made with power applied.*

Power Interface

The power connector is a 4-pin MOLEX Type connector located on the Controller unit. Two pins are used for 24VDC power. Two other pins are connected to the interlock pins on the Tuner Unit Interface connector through the control board.
The interlock can be used to provide protection against removal of the Tuner unit interface cabling. To provide this protection Pins 3 and 4 must be correctly wired into the interlock chain of the generator or system controller.
The following table lists pin functions of Power Input Connector.

Connector on the Controller Panel

Pin	Function
1	+24VDC
2	Ground
3	Interlock
4	Interlock

Tuner Unit Interface

This port transfers information between the Tuner unit and the Controller. Connection is made to the Tuner unit with the multiconductor cable provided. Connect one end of the cable to the REMOTE CONNECTOR on the Tuner unit and connect the other end to the TUNER UNIT INTERFACE connector on the Controller.

Remote Interface

This port is used when the MWH-5-01 is operated in the User Control mode. An RFC-5MW is most commonly used here as shown in Figure 2.3. However, a computer terminal or analog signals could also be used to control the MWH-5-01. To connect the RFC-5MW, simply connect the cable that comes with the RFC-5MW between this port and the RFC-5MW SERIAL I/O port. The RFC-5MW draws its power from an AC wall outlet.

Note: *If the MWH-5-01 is operated in the Automatic Control mode nothing needs to be connected to this port.*

2.4   *System Check*

Check the following items before applying power for the first time.

1.   Verify that the Controller unit's power input is of the correct voltage and connected properly as described in Sections 2.2.3 and the subsection entitled "Power Input."

2.   Ensure that all cables are connected properly and that any threaded connectors are tightened down firmly.

3.   Check for proper connection to the RF chamber.

4.   Set the generator power to minimum.

5.   Ensure that the generator is not capable of exceeding the power rating of the matching network.

6.   Guarantee that safety features, such as interlocks, are properly connected and functional.

2.5   Initial Turn On Procedure

Once you have all the equipment properly connected (see Section 2.3), the system can be powered up to check for proper operation.

The following steps outline the proper start-up procedure.

1.   Apply power to the RFC-5MW by setting its POWER switch to the ON position.

2.   Turn ON the 24VDC supply that is powering the MWH-5-01 and wait for the RESET light on the Controller unit to go out.

      After the reset you should see a display on the front panel of the RFC-5MW showing the status of the MWH-5-01. This should include a value for C1 and C2 position, a DC BIAS reading (probably 0 at this point), a PRESET location number, and the current tuning MODE (either AUTO or MAN).

3.   Apply AC power to the generator.

4.   Adjust the RF power level on the generator to zero and ensure the RF POWER switch is OFF.

5.   Press the MODE button on the RFC-5MW to select AUTO mode.

6.   Press the PSET up button as many times necessary to select PRESET A. This will set both tuning capacitors to their maximum position and the RFC-5MW should display 99 in the C1 and C2 fields.

7.   Set the chamber for the required reaction gasses and adjust the pressure to an appropriate level.

8.   Set the generator's RF power level to 100W.

9.   Turn on the generator's RF power and watch the system closely.

      At this point the MWH-5-01 tuning capacitors should start moving and the numbers on the RFC-5MW display will be changing. After a few seconds this activity should stop; the system will be tuned and the plasma in the chamber should be ignited.

10.   Turn the RF POWER OFF. The tuning capacitors should now move back to the MAX/MAX position (C1=99, C2=99).

If the system does not appear to be tuning properly, refer to Appendix 4 and 5.

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Chapter 3

MWH-5-01 Operation

3.1   Controller Unit LEDs

The MWH-5-01 Controller unit has six LEDs which indicate the operational status of the matching network. These LEDs perform the same function in all modes of operation.

LED	Function
C1 MIN/MAX	These two LEDs indicate when the C1 tuning capacitor is at one end of its travel, either minimum or maximum.
C2 MIN/MAX	These two LEDs indicate when the C2 tuning capacitor is at one end of its travel, either minimum or maximum.
RESET	This LED is on when the Controller is in a reset condition. The LED is off during normal operation.
FAULT	This LED is off during normal operation. If there is a fault in the Controller this LED blinks or may remain on permanently.

Please refer to the Mounting & Outline drawing that is included in the rear of this manual.

3.2 Modes of Operation

The MWH-5-01 is a versatile system that can be operated in a variety of ways. Many combinations of control and tuning modes are available for the user to select.

The following diagram shows the various options available:

```
        ┌──────────────────────────────┬──────────────────────────────────┐
┌─────────────────────┐              ┌──────────────────────┐
│ Automatic Control   │              │     User Control     │
└─────────────────────┘              └──────────────────────┘
         │                       ┌──────────┬──────────────┬──────────────┐
    ┌─────────┐          ┌──────────┐  Remote  ┌──────────┐ Remote ┌──────────┐
    │  Auto   │          │ RFC-5MW  │────────▶│ Analog   │◀───────│ Computer │
    │  Tune   │          └──────────┘          │ Control  │        │ Terminal │
    └─────────┘            │  Local            └──────────┘          │  Local   │
                    ┌─────────┬─────────┐  ┌────────┬────────┐  ┌────────┬────────┐
                    │  Auto   │ Manual  │  │  Auto  │ Manual │  │  Auto  │ Manual │
                    │  Tune   │  Tune   │  │  Tune  │  Tune  │  │  Tune  │  Tune  │
                    └─────────┴─────────┘  └────────┴────────┘  └────────┴────────┘
```
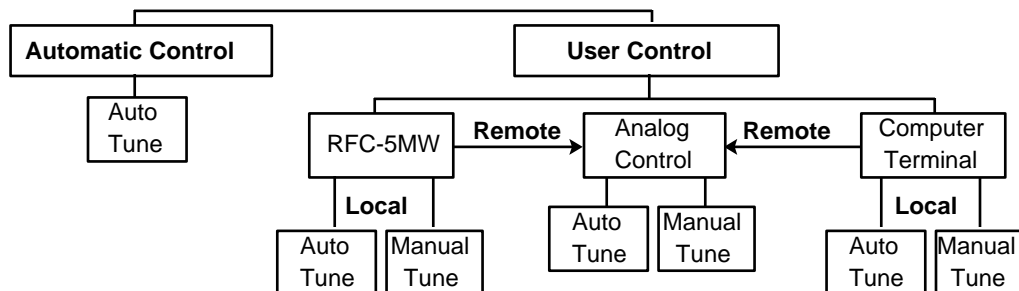
3.2.1 Control Mode

The MWH-5-01 can be directly controlled by the user or automatically controlled on its own.

User Control mode allows the user to have complete control of the MWH-5-01 using digital or analog signals on the Remote Interface port. Digital control is accomplished with the use of an RFC-5MW, computer, or terminal (See Section 3.3).

Automatic Control mode allows the MWH-5-01 to operate as a stand-alone device requiring no user interaction. The unit will be locked into Auto Tune mode, thereby automatically tuning into the chamber whenever RF power is detected (See Section 3.4).

The control mode is selected by DIP Switch #12 inside the MW Controller unit (See Appendix A, Section A.3).

3.2.2 Local/Remote Operation

When operating in User Control mode, a digital device must be used to communicate with the MWH-5-01. This could be an RFC-5MW, computer, or terminal. However, the digital device may be disabled to allow analog DC voltages to control the MWH-5-01. The user may select between Local control, using the digital device; or Remote control, using the analog signals. This selection is made from the digital unit.

3.2.3   Tuning Mode

The MWH-5-01 can be set to tune manually or automatically. The following sections in this chapter describe the many different ways to move the tuning capacitors while in Manual Tune mode. In Auto Tune mode the MWH-5-01 will automatically set the tuning capacitors to achieve the best possible match with the chamber. Accurate tuning is achieved by the MWH-5-01's microprocessor based control, derived from input signals from the Phase/Mag sensors mounted in the Tuner unit.

3.3   User Controlled Operation

When the MWH-5-01 is operated in the User Control mode, three options are available to control the MWH-5-01 through the Remote Interface port:

- Local control with an RFC-5MW
- Local control with a computer or terminal
- Remote Analog control using DC voltages on the port

3.3.1   Local Operation with an RFC-5MW

The RFC-5MW is a digital unit that communicates with the MWH-5-01 through the digital portion of the remote interface. It is designed specifically to ease the task of controlling the matching network. This is accomplished through the use of the RFC-5MW's front panel, which is divided into two major sections. The first section is a two-line, twenty-column fluorescent display used to monitor the status of the MWH-5-01. The second section is a set of eleven push-button switches that are used to control such functions as capacitor movement, tuning mode selection and tune position storage.
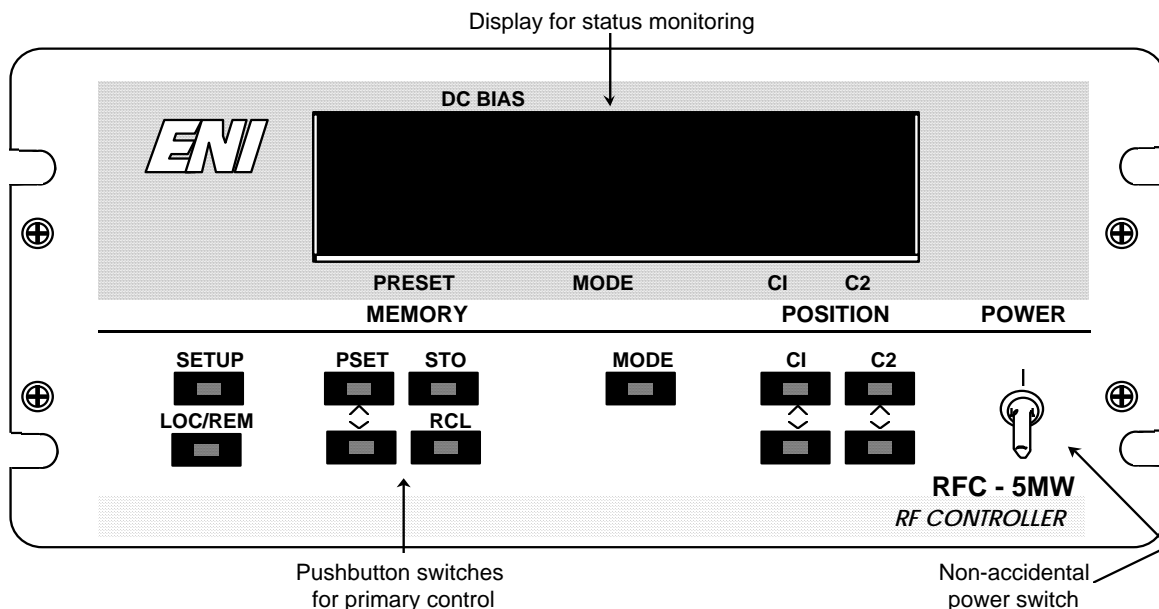
RFC-5MW Front Panel
Figure 3.3.1

RFC-5MW Front Panel Display

The fluorescent display is divided into five fields for monitoring the MWH-5-01 status.

Display Field	Description
MODE	Shows the present mode of the matching network. This field will contain one of three settings: • MAN Manual tuning mode • AUTO Automatic tuning mode • REM Remote control via analog signals
PRESET	Shows the currently selected preset location.
DC BIAS	Shows the DC bias, measured in volts, at the output stud of the matching network.
C1	Shows the present position of tuning capacitor C1.
C2	Shows the present position of tuning capacitor C2.

RFC-5MW Front Panel Display
Table 3.3.1.1

RFC-5MW Front Panel Buttons

The eleven pushbutton switches on the RFC-5MW are described below.

Pushbutton	Function
SETUP	This button allows the RFC-5MW configuration to be adjusted. Refer to your RFC-5MW manual for more information.
LOC/REM	This button selects between Local control or Analog Remote control. Local control is the standard mode where the RFC-5MW buttons are used to control the MWH-5-01. When set to REM mode, the RFC-5MW push buttons have no effect; control is accomplished via analog signal on the Remote Interface port (See Section 3.3.3).
MODE	This button selects between manual tune mode (MAN) and automatic tune mode (AUTO).
PSET ∧ ∨	These two buttons cycle up or down through the presets to select a new preset location. Once a preset location has been selected the number in the preset field will start to flash.
STO	This button stores the present tuning capacitor positions after a preset location has been selected. When the button is pressed, the positions are stored and the preset field stops flashing. This button is only active in MAN mode.
RCL	This button recalls the tuning capacitor positions from the currently selected preset location. When the button is pressed the positions are recalled and the preset field stops flashing.
C1 ∧ ∨	These two buttons are only active in MAN mode. They allow the operator to manually move the C1 tuning capacitor position up or down from 0 to 99 percent mesh. If a button is held down the capacitor will continue moving in the chosen direction until it reaches its end point.
C2 ∧ ∨	These two buttons are only active in MAN mode. They allow the operator to manually move the C2 tuning capacitor position up or down from 0 to 99 percent mesh. If a button is held down the capacitor will continue moving in the chosen direction until it reaches its end point.

RFC-5MW Front Panel Push buttons
Table 3.3.1.2

Manual Tuning Using an RFC-5MW

To manually tune the MWH-5-01 system, press the MODE button to select MAN mode. Use the C1 up and down buttons to adjust the position of the C1 tuning capacitor. Use the C2 up and down buttons to adjust the position of the C2 tuning capacitor. Adjust C2 for course tuning adjustments and C1 for fine-tuning adjustments while monitoring your reflected power on the generator. Continue to adjust the two tuning capacitors until a good match is achieved. You should be able to tune the system with reflected power less than 1W.

To save this tune position, if so desired, press the PSET up or down buttons to select one of the ten preset locations. The selected location should start flashing in the PRESET field on the display. Now press the STO button to store the tune position in the MWH-5-01's Controller memory. The preset number will stop flashing after pressing the STO button.

To recall this or any stored tune position, simply press the PSET up or down buttons to select the desired preset location then press the RCL button to recall the setting. The MWH-5-01 will instantly respond by moving the tuning capacitors to the previously stored positions.

Auto Tuning Using an RFC-5MW

To let the MWH-5-01 auto tune first ensure that RF power is OFF. Press the MODE button to select AUTO mode. Use the PSET buttons to select one of the ten standard preset locations (0 - 9), or one of the special Auto mode locations (A - C). In Auto mode the C1 and C2 positions will automatically be recalled as you cycle through the preset locations. Pressing the RCL button is not necessary.

These recalled positions will become the MWH-5-01's auto tune starting point. Now apply RF power. The tuning capacitors will start moving until the MWH-5-01 locates the best possible tune point. Within a few seconds the MWH-5-01 will stop moving its capacitors and the system should be tuned with a reflected power less than 1% or 1W max. of the forward power.

The three special preset locations available in AUTO mode are described as follows:

PRESET A	Always start tuning from MAX/MAX. C1 = 99 and C2 = 99.
PRESET B	The tuning capacitors will start from the position they were at when RF power was last turned off; typically the last tuned position. This is called the STAY mode.
PRESET C	Starts tuning from a preset position as set by analog voltages on the Remote Interface port.

3.3.2 Local Operation with a Computer or Terminal

If you choose not to use an RFC-5MW, digital communications can be accomplished with a host computer or host terminal through the digital portion of the Remote Interface. Commands are sent from the host to control and monitor the status of the MWH-5-01.

Digital Communications on the Remote Interface

The digital portion of the Remote Interface uses standard RS-232 or RS-422 signals to communicate with the host. The interface supports 7 or 8 data bits, parity, 1 or 2 stop bits, and data rates up to 19.2k baud. These interface parameters are configurable by the DIP switches in the Controller unit (See Appendix 3).

Before communications can begin it is necessary to set the host for the same data format (baud rate, number of data bits, parity, stop bits), as the MWH-5-01.

The default configuration on the MWH-5-01 is as follows:

| 9600 Baud | 8 Data Bits | 1 Stop Bit | No Parity |

RS-232 or RS-422 operation is selected by a pair of three pin jumpers on the control board (J3 and J4) inside the Controller unit as shown below.

	RS-232	RS-422
J3	1-2	2-3
J4	1-2	2-3

	RS-232	RS-422
P4	1-2	2-3
P3	1-2	2-3
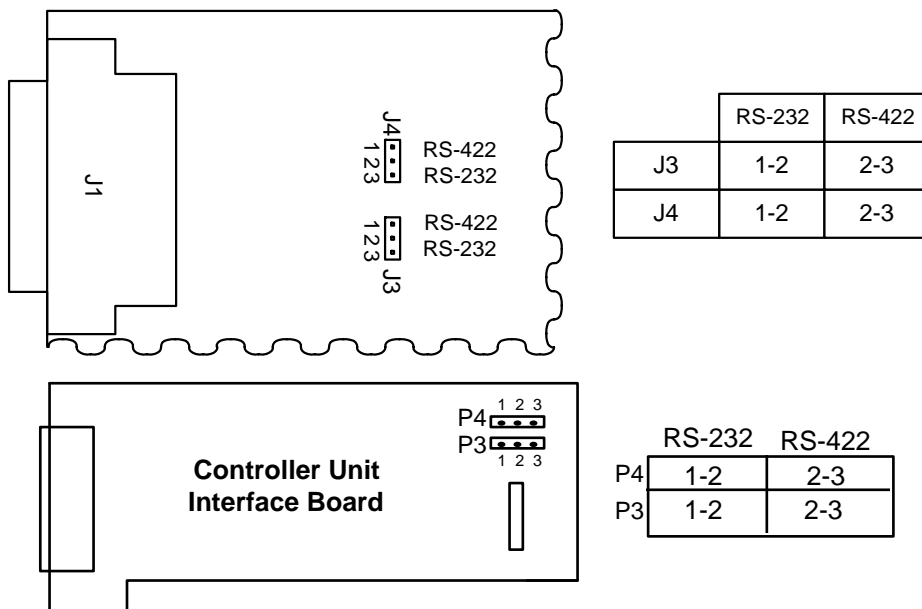
Digital Communications Configuration Options
Figure 3.3.2.1

The following table specifies the function of each of the pins in the digital portion of the REMOTE INTERFACE connector:

Pin	Name	Function
2	Tx Data	This RS-232 output transmits data from the Controller unit.
3	Rx Data	This RS-232 input receives data from the host.
5	CTS	This RS-232 input controls the flow of data from the Controller.
20	DTR	This RS-232 output indicates that the Controller is ready for communications.
7	Digital Ground	This pin is connected to the digital ground of the Controller.
24 / 14	RS-422 OUT	Pin 24 is the (+) side and Pin 14 the (-) side of the RS-422 balanced pair that transmits data from the Controller unit.
15 / 16	RS-422 IN	Pin 15 is the (+) side and Pin 16 the (-) side of the RS-422 balanced pair that receives data from the host.
12 / 13	RS-422 CTS	Pin 12 is the (+) side and Pin 13 the (-) side of the RS-422 balanced input pair that controls the flow of data from the Controller.
18 / 19	RS-422 DTR	Pin 18 is the (+) side and Pin 19 the (-) side of the RS-422 balanced output pair that indicates the Controller is ready for communications.

RS-232 Connection to a Standard Computer or Terminal

Most computers and terminals have a serial port that uses the RS-232 interface standard via a 25-way 'D' connector. More recent IBM PC compatible computers use a 9-way 'D' connector.

When using RS-232 communications it is only necessary to use three signals on the MWH-5-01 Remote Interface connector. These signals are:

Tx Data	Pin 2
Rx Data	Pin 3
Digital Ground	Pin 7

The connecting cable must be wired such that Tx Data from the host goes to Rx Data on the MWH-5-01 and Tx Data from the MWH-5-01 goes to Rx Data on the host. In effect, the Tx Data and Rx Data lines are "cross-coupled". The digital ground must also be connected between the host and MWH-5-01.

Typical PC Connection:

25 -Way Female 'D'   25 -Way Male 'D'

Host   Rx   2   2 Tx   **Remote**
PC   Tx   3   3 Rx   **Interface Connector**
         GND 7   7 GND
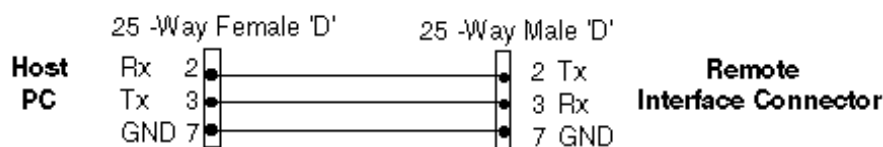
If your PC compatible uses a 9-pin 'D' connector for its RS-232 port, the cable is wired as shown above except you must use Pin 5 for GND on the PC connector instead of Pin 7.

WYSE Terminal Connection:

25 -Way Female 'D'   25 -Way Male 'D'

Host   Tx   2   2 Tx   **Remote**
Terminal   Rx   3   3 Rx   **Interface Connector**
         GND 7   7 GND
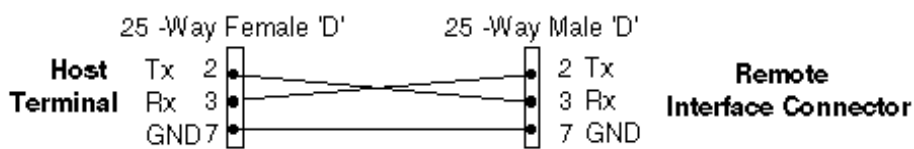
MWH-5 Remote Interface Connectors

When making a cable, ensure that connections are not made to the analog portion of the REMOTE INTERFACE connector. These voltage levels are incompatible with RS-232 signals and damage could occur.

RS-422 Bussing

If you are using RS-422 signals on the Remote Interface one controlling computer (or terminal) can be connected to multiple digital MATCHWORK® units. Up to sixteen systems can be bussed together by connecting the RS-422 receive and transmit d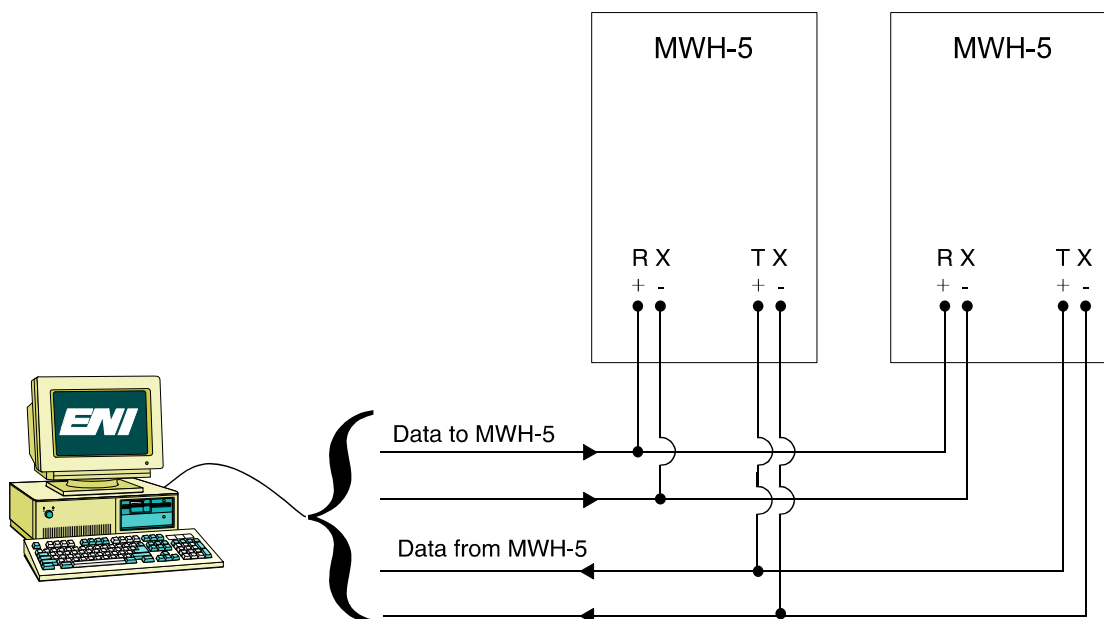ata lines in parallel as shown in the following diagram. However, each unit must be set for a specific RS-422 address. When this mode of operation is used it is necessary to use the IDE command and link release character in the section entitled "Link Release Character."

MWH-5   MWH-5

R X   T X   R X   T X
+ -   + -   + -   + -

Data to MWH-5

Data from MWH-5

Multiple MATCHWORK® Connections to a Host
Figure 3.3.2.2

To set an MWH-5-01 for a specific address, you must change DIP Switches #1-4 on the control board in the Controller unit. All digital MATCHWORK® Controllers come from the factory set for an address of 0.

The table below shows how to set DIP Switches #1-4 for a different address.

Address	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Switch 1	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF	ON	OFF
Switch 2	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF	ON	ON	OFF	OFF
Switch 3	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
Switch 4	ON	ON	ON	ON	ON	ON	ON	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF

DIP Switch Selection
Table 3.3.2.3

3.3.3   Communications Protocol

Data is transferred to and from the MWH-5-01 using a simple ASCII protocol which functions with a standard terminal. Whether you are using RS-232, RS-422, bussing or not, the communications protocol and commands are the same.

Command Structure

All commands are composed of three letter characters, followed by numbers where applicable, and terminated by a carriage return. All command characters must be correct for a command to be accepted. Since all characters are echoed, the controlling computer or terminal can check that the commands were correctly received by comparing the echoed characters with what was sent.

Commands containing numerical fields will only be accepted if the numerical portion is in a specified range depending upon the command.

Upon receipt of a carriage return ($0D) the Controller returns a carriage return ($0D) and a line feed ($0A) so that the terminal screen is correctly formatted. If the command was correctly received in the proper format a star prompt (*) is returned. If a bad command is received an error prompt is returned which consists of a bell character ($07) and a question mark (?). The two responses are ordered as follows:

Correct Response: [CR] [LF] [*]

Error Response: [CR] [LF] [BELL] [?]

The protocol **always** returns one of these two responses after command execution.

Illegal Commands

Unrecognized commands or out-of-range numerical values are ignored and enunciated by the return of the error response. The same occurs if the limits of the line buffer are exceeded (16 characters). Note that a carriage return on its own is a valid command that does nothing (no operation).

Space Characters

To allow screen formatting, space characters ($20) are echoed on the serial link. However, they are ignored for command information.

Leading Zeros

The numerical part of a command need not contain leading zeros, although leading zeros will be echoed and accepted if they are sent. If a numerical field is empty it is assumed to be zero.

Backspace Characters

Backspace or delete characters ($08) or ($7F) allow limited editing. When either one of these characters is received the last character in the line buffer is deleted and the following three characters are returned on the serial link:

[BS] [SPACE] [BS]

This ensures that a terminal screen backspaces its cursor and removes the last character.

Special Characters

Five characters have a special purpose and are the only characters not echoed on the serial link. The escape character ($1B) allows the operator to break out of continuous loops. The CONTROL-W character (^W) is used to maintain link integrity. The exclamation mark (!) is used to cause an immediate release of the RS-422 buffer if two consecutive exclamation marks are received in a row. The XON and XOFF characters (^Q and ^S) allow flow control of the serial data.

Escape from Indefinite Loops

Some commands can be made to continue indefinitely with the use of the dash <-> option. The escape character ($1B) or ESC key are used to exit from this condition. Upon receipt of the escape character the Controller will terminate the loop and respond with the standard command completion string.

XON and XOFF

When XOFF is received (^S) transmission of serial data from the Controller is halted. When XON is received (^Q) transmission of serial data will resume.

Power-Up Message

Power up is confirmed by a special message terminated by a special prompt, a star enclosed in curly brackets {*}. This is the only time that this prompt is used; therefore, a controlling computer can use this to see that a unit has powered up correctly.

The complete power up string is as follows:

[CR] [LF] [message string] [CR] [LF] [BELL] [{] [*] [}]

3.3.4   MWH-5-01 Commands

The MWH-5-01 has a set of low-level commands that are used to control and monitor the status of the system. These commands are intended to be used for creating software control programs for the MWH-5-01. However, the user can use these commands individually for testing and debugging the system.

The commands are grouped into four categories:

- Basic Monitor Commands
- Mode Selection Commands
- Tune Control Commands
- Status Readback Commands

Many of the commands have options available that are shown in brackets (< >) after the command. When these options are used the brackets should **not** be included in the command. For example, if you wish to view Help Screen Number 3, type HEL 3 not HEL <3>.

Basic Monitor Commands

This set of commands allow limited access to the Controller software:

Command	Function
HEL <n>	Displays on-line help screens. HEL by itself will show a menu of available help screens. To view a specific help screen use the <n> option where <n> is the number of the specific screen.
CHK <x-y>	Calculates the checksum of the selected program range from x to y. The checksum is a simple additive type where each byte is added to the next for a final total. If you use the address range of 0000-FFFF, the last four digits of the number returned should match the firmware number listed on the ROM label in the Controller unit.
IDE <n>	This command is used for RS-422 bus switching. <n> is a value from 0-15 corresponding to the address of the Controller you wish to select. The Controller address is selected by DIP switches inside the Controller unit (see section 3.3.2.3).
!!	This command is called "Link Release" and is used for RS-422 bus switching. When two exclamation marks are sent in a row all listening Controllers will try-state their RS-422 output. This is done to avoid data collisions if multiple Controllers are being used. The proper way to switch from one Controller to another is to execute Link Release (!!) and then use the IDE command to select the new Controller.

Mode Selection Commands

The following commands are used to select the control mode of the MWH-5-01:

Command	Function
REM	Places the MWH-5-01 into Analog Remote Control mode. When using this mode the tune control commands will have no effect. Use of these commands will return the standard error prompt. However, all readback commands will still function. Control is accomplished via analog signals on the Remote Interface (See Section 3.3.5).
LOC	Places the MWH-5-01 into Local Control mode. In this mode the tune control commands are used to control the system. Analog signals on the Remote Interface port are ignored.
TLR	Toggles the MWH-5-01 between LOC and REM mode.
TAM	When operating in LOC mode, this command will toggle the MWH-5-01 between Auto Tune mode and Manual Tune mode. This command will return the standard error response if used in REM mode.

Tune Control Commands

These commands provide control of the tuning functions for the MWH-5-01 system. All commands with the <n> option allow parameters to be passed. If parameters are omitted it will be assumed to have a value of 0.

Command	Function
SCO <n>	Sets the C1 tuning capacitor position.
	<n> is a decimal number from 0-99 representing the position in percent meshed. This command can only be used in manual tune mode.
SCT <n>	Sets the C2 tuning capacitor position.
	<n> is a decimal number from 0-99 representing the position in percent meshed. This command can only be used in manual tune mode.
G01 <n>	Sets the C1 tuning capacitor position.
	<n> is a hex number from 00-63 representing the position in percent meshed. This command can only be used in manual tune mode.
G02 <n>	Sets the C2 tuning capacitor position.
	<n> is a hex number from 00-63 representing the position in percent meshed. This command can only be used in manual tune mode.
ICO	Increments the C1 tuning capacitor by one step.
DCO	Decrements the C1 tuning capacitor by one step.
ICT	Increments the C2 tuning capacitor by one step.
DCT	Decrements the C2 tuning capacitor by one step.
	These commands can only be used in manual tune mode.
ADJ	Displays a menu that allows for adjustment of the C1 and C2 tuning capacitors while simultaneously monitoring their position. Adjustment is made by pressing keys on the keyboard. This command is only available in manual tune mode and is intended for debugging use only.
IPR	Increments the preset location by one.
DPR	Decrements the preset location by one. In manual tune mode these commands will cycle through preset locations 0-9. In auto tune mode these commands cycle through preset locations 0-9 and special modes A-C.
	Each time one of these commands is executed in auto tune mode the tuning capacitor positions will be instantly recalled from the new location.

Tune Control Commands, Continued:

Command	Function
STO <n>	Stores the present C1 and C2 tuning capacitor positions in a specified preset location.
	<n> is a value from 0-9 or <=> that specifies the preset location. If <=> is used, the capacitor positions will be stored in the currently selected preset location. This command can only be used in manual tune mode.
RCL <n>	Recalls the C1 and C2 tuning capacitor positions from a specified preset location.
	<n> is a value from 0-9 or <=> that specifies the preset location. If <=> is used, the capacitor positions will be recalled from the currently selected preset location. This command can only be used in manual tune mode.
MOD <n>	Sets the tuning capacitors starting point for auto tune mode by changing the current preset location.
	<n> is one of the standard preset locations 0-9 or special locations A-C.
	If this command is executed in manual tune mode, the current preset location will not change until the TAM command is used to switch to auto tune mode.

The three special preset locations available in Auto Tune mode are described as follows:

PRESET A	Always starts tuning from MAX/MAX C1 = 99 and C2 = 99.
PRESET B	Tuning capacitors will start from the position they were at when RF power was last turned off; typically the last tuned position. This is called the STAY mode.
PRESET C	Starts tuning from a preset position as set by analog voltages on the Remote Interface port.

Status Readback Commands

This set of commands is used to read back information on the current state of the MWH-5-01. Commands shown with the dash option <-> can be followed by a dash for continuous readback. To stop the continuous readback of these commands press the ESC key on the keyboard or send the ESC character ($1B) from your software.

Command	Function
RDC <->	Returns the DC bias voltage on the system.
RPP <->	Returns the peak-to-peak voltage measured at the output stud. This command is only useful if the optional Vpp circuit is installed in the Controller unit. If the circuit is not installed garbage values will be returned.
RCO <->	Returns the current position of the C1 tuning capacitor in terms of percent meshed (0-99).
RCT <->	Returns the current position of the C2 tuning capacitor in terms of percent meshed (0-99).
RPS	Returns a two-digit hex number that represents the current operating status of the MWH-5-01. The first digit (most significant digit) shows the current operating mode. Values range from 1-3: 1 = Manual Tune Mode 2 = Analog Remote Control Mode 3 = Auto Tune Mode The second digit (least significant digit) shows the currently selected preset location. Values representing the preset location range from 0-9 and A-C.

Status ReadBack Commands, Continued:

Command	Function
ACT <->	Returns status information on the MWH-5-01 in a batch format for quick processing. The information sent is a packet of all five commands described above. The packet is sent in the following order: | RDC	RPP	RCO	RCT	RPS | This command is intended mostly for software programming, as the fields in the packet are **not** separated by any spaces. Each field is five characters long except RPS, which is only two characters.
RFV <=>	Returns a 16-bit value formatted as 4 hex digits. The first digit is the most significant digit and the last digit is the least significant digit. This value is known as the "Fault Vector". Bit definitions are as follows: *Digit 1* *Bit 15 Spare* *Bit 14 Controller Hardware Fault* *Bit 13 Code ROM Fault* *Bit 12 External RAM Fault (DS1225)* *Digit 2* *Bit 11 Internal RAM Fault (80C552)* *Bit 10 Spare* *Bit 9 Spare* *Bit 8 Spare* *Digit 3* *All bits are currently unused.* *Digit 4* *All bits are currently unused.* If the <=> option is used the faults are returned in plain English instead of a hex number. This is useful for debugging purposes.
RUT <=>	Returns the amount of time the MWH-5-01 has been powered on. If RUT is typed alone the value returned is the amount of time in hours only. If the <=> option is used the value returned will be in the HH.MM.SS format.
RVE	Returns the version number of the software installed in your Controller unit. This should match the version number printed on the ROM label in the Controller unit.

3.3.5   Remote Operation with Analog Signals

Another option for controlling the MWH-5-01 is through the analog portion of the Remote Interface port. To use these analog signals the MWH-5-01 must be set for Analog Remote operation. This is accomplished by pressing the LOC/REM button on the RFC-5MW to set REM mode or using the REM command from a computer or terminal.

Once this mode is engaged, the pins on the analog portion of the Remote Interface connector may be used as described in the table below.

Pin	Name	Function
9	+15V Power	**Output:** A +15VDC power output for user connections. Current is limited to 30mA with a 470Ω resistor.
25	Analog Ground	**Ground**: This is the ground reference for all of the analog signals.
6	Auto/Man	**Input:** This input is used to select between Auto tune and Manual tune modes. When this pin is left open the MWH-5-01 will be set to Auto tune mode. When this pin is connected to Ground (Pin 25), the MWH-5-01 will be set to Manual tune mode.
10	C1 Position	**Output**: A DC voltage between 0 and 10V that indicates the position of the C1 tuning capacitor. 0V = 0% meshed. 10V = 100% meshed.
4	C2 Position	**Output**: A DC voltage between 0 and 10V that indicates the position of the C2 tuning capacitor. 0V = 0% meshed. 10V = 100% meshed.
8	C1 Control	**Input**: A DC voltage between 0 and 10V that sets the position of the C1 tuning capacitor when the unit is in Manual Tune mode. 0V = 0% meshed. 10V = 100% meshed.
11	C2 Control	**Input**: A DC voltage between 0 and 10V that sets the position of the C2 tuning capacitor when the unit is in Manual Tune mode. 0V = 0% meshed. 10V = 100% meshed.
22	DC Bias	**Output**: A DC voltage between 0 and 10V that represents the DC bias level on the MWH-5-01. 1V output = 284.3V DC bias.
17	Power ON Monitor	**Output:** An open collector signal that indicates when the MWH-5-01 power is turned on.

Tuning Mode Selection

When using Analog Remote Control, the tuning mode is selected by changing the state of Pin 6 (Auto/Man Select) on the Remote Interface connector.

This input runs through the input side of an opto-isolator pulled up to +15V through a 1.0kΩ resistor and a 6.2V zener diode. When this input is left open, no current will flow through the opto-isolator, thus leaving it off and selecting Auto tune mode. When this input is grounded current will flow through the opto-isolator (approximately 5mA), turning it on and therefore selecting Manual tune mode.

Auto Tune Mode

This mode is selected by leaving the Auto/Man select input open.

In this mode the system will auto tune whenever RF is detected. The starting position for the tuning capacitors will be the positions stored in the preset location selected prior to entering Analog Remote mode.

The position of the tuning capacitors can be read by the C1 and C2 position voltages on Pins 10 and 4, respectively.
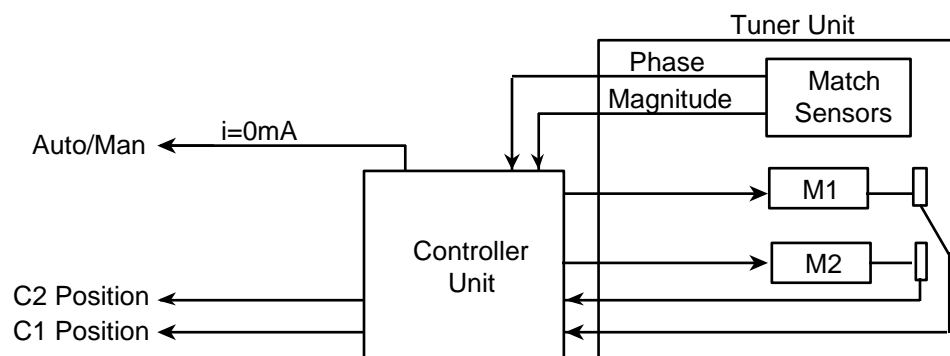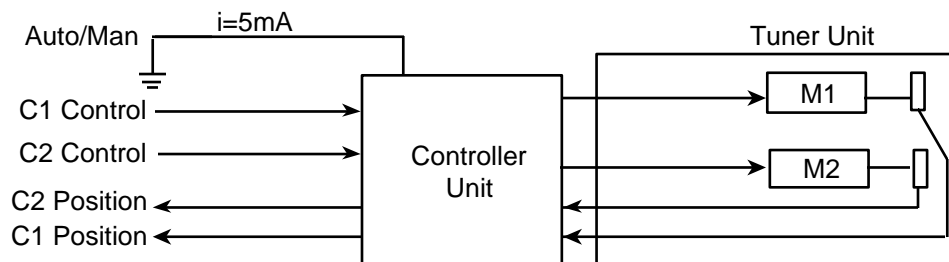
Manual Tune Mode

This mode is selected by grounding the Auto/Man select input.   Use ground on Pin 25.

In this mode separate DC voltages on the C1 and C2 control inputs are used to set the position of the individual tuning capacitors.

The position of each tuning capacitor can be read by the C1 and C2 position voltages on Pins 10 and 4, respectively.

3.4   *Automatic Control Mode*

The MWH-5-01 can be set up to operate as a stand-alone unit. This is accomplished by setting DIP Switch #12 to the ON position, thereby selecting the Automatic Control mode.

When the MWH-5-01 is set for automatic control the system is locked into Auto Tune mode and will therefore auto tune whenever RF power is detected.   When RF power is shut off the capacitors will move to the preselected starting point. The starting point is one of the standard preset locations, 0-9 or special locations A-B. Preset C is not a valid option in the Automatic Control mode.

The starting point is selected by setting DIP Switches #1-4 on the control board in the Controller unit. Usually these switches control the RS-422 bus address. However, the function of these four switches changes when DIP Switch #12 is ON.

The following table shows how to set DIP Switches #1-4 to select the desired preset location.

1 — **Preset Select 0**				
2 — **Preset Select 1**				
3 — **Preset Select 2**				
4 — **Preset Select 3**				

4	**3**	**2**	**1**	Location
ON	ON	ON	ON	PRESET 0
ON	ON	ON	OFF	PRESET 1
ON	ON	OFF	ON	PRESET 2
ON	ON	OFF	OFF	PRESET 3
ON	OFF	ON	ON	PRESET 4
ON	OFF	ON	OFF	PRESET 5
ON	OFF	OFF	ON	PRESET 6
ON	OFF	OFF	OFF	PRESET 7
OFF	ON	ON	ON	PRESET 8
OFF	ON	ON	OFF	PRESET 9
OFF	ON	OFF	ON	PRESET A
OFF	ON	OFF	OFF	PRESET B

5
6
7
8
9
10
11
12 — **Control Mode Select = ON**

PRESET A	Always starts tuning from MAX/MAX. C1 = 99 and C2 = 99.
PRESET B	The tuning capacitors will start from the position they were at when RF power was last turned off; typically the last tuned position. This is called the STAY mode.

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Appendix A

MWH-5 Specifications & Connectors

This section contains the following information:

A.1 Technical Specifications

MWH-5-01 Specifications

Rated RF Power	5000VA
Frequency	13.56MHz
Input Impedance	50Ω
Tune Range	Configurable, see fig. A1
Tune Response Time	Less than 10 seconds
Maximum Reflected Power at Tune Point	Less than 1% of measured forward power (or 1W when optimized for a specific chamber)
RF Input Connector	Type 'N'
RF Output Connection	Strap
Operating Temperature	0-45°C ambient
Cooling	Forced air via internal fan.
Power Required	24VDC, ±10%, 4 A peak, <2 A nom.
Operation	Selectable: automatic control (stand-alone) or full user control.
Pre-positioning	Independent setting for both variable capacitors from 0 - 100% meshed.
Capacitor Position Outputs	Where0V = 0% meshed 10V = 100% meshed
DC Bias Output	3.52V per kV; nom. 284.3:1 divider
Control Input Connector	25-pin female 'D'

<u>Size:</u> **(H x W x D)**	Tuner Unit	*121 x 204 x 320mm* 4.75 x 8.0 x 8.0"
	Controller Unit	*320 x 204 x 220mm* 1.25 x 8.0 x 8.65"
<u>Weight:</u>	Tuner Unit	10.0 lbs *(4.54kg)*
	Controller Unit	1.0 lbs *(0.45kg)*
Remote Control Interface		RS-232 or RS-422 (jumper-selectable), and analog control.
Protocol		All controllable parameters available which includes analog pre-position and control

Figure A1. Attached Smith chart shows the allowed load impedance range of the Matching network, and the internal setup used to achieve this.

Tune Range

Smith Chart $Z_O = 50 \cdot \Omega$

Component Values Used:

$C1min = 50 \cdot pF$

$C1max = 1500 \cdot pF$

$C1pad = 780 \cdot pF$

$L = 0.27 \cdot \mu H$

$C2min = 20 \cdot pF$

$C2max = 250 \cdot pF$

$C2pad = 0 \cdot pF$

$C3 = 900 \cdot pF$

$Z_{load_{0,0}} = 3.343 - 0.278j \cdot \Omega$
        C1min, C2min
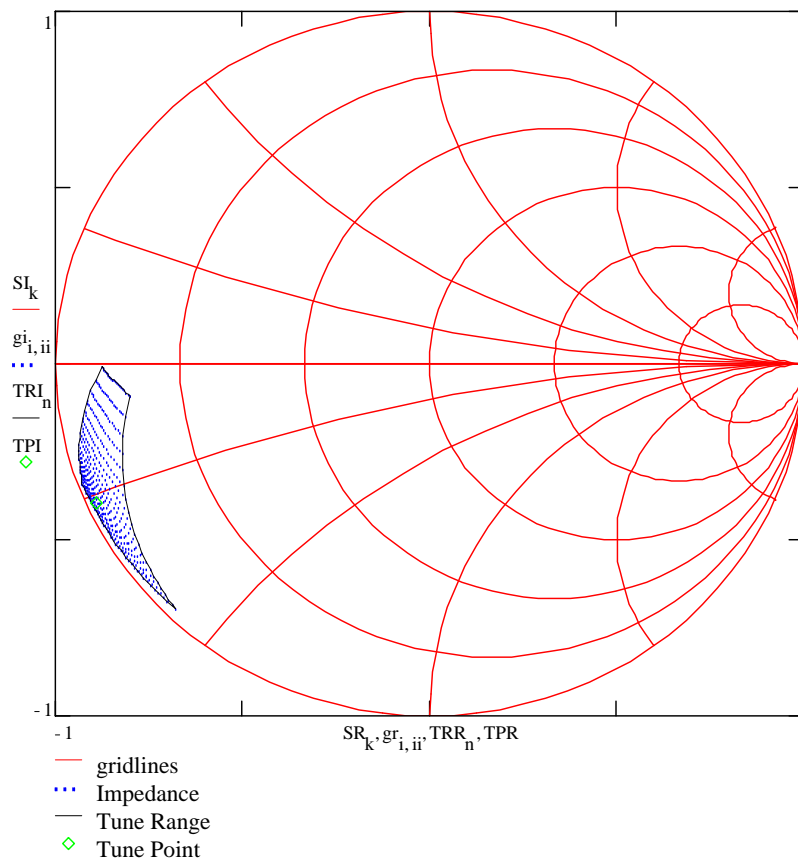
$Z_{load_{N,0}} = 0.309 - 8.872j \cdot \Omega$
        C1max, C2min

$Z_{load_{0,N}} = 5.393 - 2.767j \cdot \Omega$
        C1min, C2max

$Z_{load_{N,N}} = 0.834 - 21.077j \cdot \Omega$
        C1max, C2max

SI_k
——
$gi_{i,ii}$
...
TRI_n
——
TPI
◇

$SR_k, gr_{i,ii}, TRR_n, TPR$

—— gridlines
... Impedance
—— Tune Range
◇ Tune Point

The output impedance range of the network is the complex conjugate of the load impedance range. This would be viewed looking back into the output, with the MATCHWORK® input terminated with 50 ohms.

A.2   Controller Unit and Tuner Unit Connectors

Controller Unit Connectors

The following pages describe the pin-out for each of the connectors on the Controller unit.

Connector	Pin-out Shown On:
Power Input	A - 6
Tuner Unit Interface	A - 7
Remote Interface	A - 8

Tuner Unit Connectors

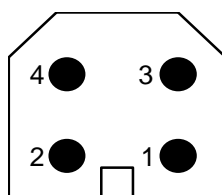The following pages describe the pin out for each of the connectors on the Controller unit.

Connector	Pin out shown on:
Tuner Unit Remote Connector	A - 9

Power Interface

The power connector is a 4-pin MOLEX Type connector located on the Controller unit. Two pins are used for 24VDC power. Two other pins are connected to the interlock pins on the Tuner Unit Interface connector through the control board.
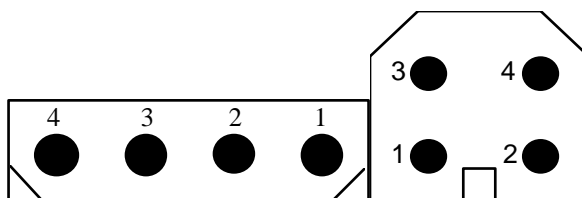
The interlock can be used to provide protection against removal of the Tuner unit interface cabling. To provide this protection Pins 3 and 4 must be correctly wired into the interlock chain of the generator or system controller.

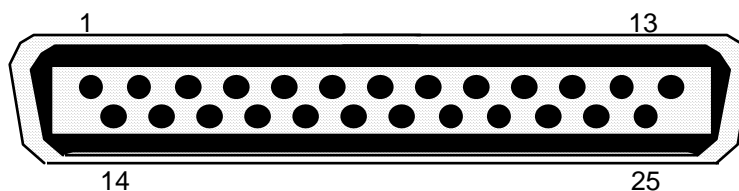The following table lists pin functions of Power Input Connector.

Connector on the Controller Panel

Pin	Function
1	+24VDC
2	Ground
3	Interlock
4	Interlock

Tuner Unit Interface Connector

This connector is a 25-way male connector. The following table provides a description of each pin on the Tuner Unit Interface connector.
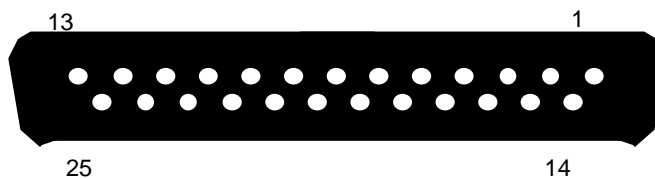
Pin	Name	Description
1	M2 (+)	**Output:** C2 Motor Drive (positive side)
2	M2 (+)	Same as Pin 1
3	M1 (+)	Same as Pin 4
4	M1 (+)	**Output:** C1 Motor Drive (positive side)
5	INTL 1	**Input:** Optional Input for Tuner Interlock Switch
6	MAG (+)	**Input:** Phase/Mag Sensor Input
7	MAG (-)	**Input:** Phase/Mag Sensor Input
8	C2 POS	**Input:** C2 Position Voltage
9	POS REF	**Output:** +5VDC Reference Voltage for C1 and C2 POS
10	PHASE (-)	**Input:** Phase/Mag Sensor Input
11	M1 (-)	**Output:** C1 Motor Drive (negative side)
12	PHASE (+)	**Input:** Phase/Mag Sensor Input
13	- - - -	No Connection
14	GND	System Ground
15	INTL 2	**Input:** Optional Input for Tuner Interlock Switch
16	AIR SW	**Input:** Fan Interlock Signal *
17	FAN (+)	**Ouput:** Power for Tuner Unit Fan *
18	FAN (-)	**Ouput:** Power for Tuner Unit Fan *
19	C1 POS	**Input:** C1 Position Voltage
20	M1 (-)	Same as Pin 11
21	+15VDC	**Output:** User Voltage (30mA Maximum)
22	M2 (-)	Same as Pin 24
23	DC BIAS	**Input:** DC Bias Detector Voltage
24	M2 (-)	**Output:** C2 Motor Drive (negative side)
25	GND	System Ground

* *These signals are only used on air-cooled units.*

Remote Interface Connector

This connector is a 25-way female connector. The following table provides a description of each pin of the Remote Interface connector.
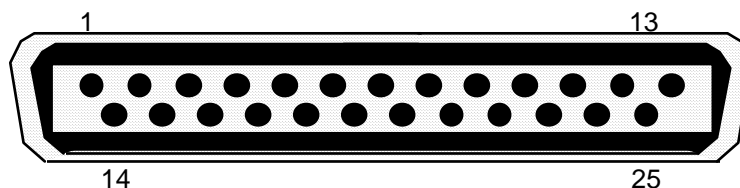

Pin	Name	Description
1	- - - -	No Connection
2	TX- DATA	**Output:** RS-232 Transmit Data
3	RX- DATA	**Input:** RS-232 Receive Data
4	C2 POS	**Output:** C2 Position Voltage
5	CTS	**Input:** RS-232 Clear to Send
6	AUTO/MAN	**Input:** Auto/Man Tune Mode Select
7	DGND	Digital Ground
8	C1 CONTROL	**Input:** C1 Control Voltage
9	+15VDC	**Output:** User Voltage (30mA Maximum)
10	C1 POS	**Output:** C1 Position Voltage
11	C2 CONTROL	**Input:** C2 Control Voltage
12	CTS (+)	**Input:** RS-422 Clear to Send
13	CTS (-)	**Input:** RS-422 Clear to Send
14	RS-422 OUT (-)	**Output:** RS-422 Transmit Data
15	RS-422 IN (+)	**Output:** RS-422 Receive Data
16	RS-422 IN (-)	**Input:** RS-422 Receive Data
17	POWER ON	**Output:** Power Monitor (O.C. Output)
18	DTR (+)	**Output:** RS-422 Data Terminal Ready
19	DTR (-)	**Output:** RS-422 Data Terminal Ready
20	DTR	**Output:** RS-232 Data Terminal Ready
21	- - - -	No Connection
22	DC BIAS	**Output:** DC Bias Monitor Voltage
23	- - - -	No Connection
24	RS-422 OUT (+)	**Output:** RS-422 Transmit Data
25	AGND	Analog Ground

Tuner Unit-Remote Connector

This connector is a 25-way male connector. The following table provides a description of each pin on the Remote Connector.

Pin	Name	Description
1	M2 (+)	**Input:** C2 Motor Drive (positive side)
2	- - - -	No Connection
3	- - - -	No Connection
4	M1 (+)	**Input:** C1 Motor Drive (positive side)
5	INTL 1	**Output:** From Optional Tuner Interlock Switch
6	MAG (+)	**Output:** Phase/Mag Sensor Output
7	MAG (-)	**Output:** Phase/Mag Sensor Output
8	C2 POS	**Output:** C2 Position Voltage
9	POS REF	**Input:** +5VDC Reference Voltage for C1 and C2 POS
10	PHASE (-)	**Output:** Phase/Mag Sensor Output
11	M1 (-)	**Input:** C1 Motor Drive (negative side)
12	PHASE (+)	**Output:** Phase/Mag Sensor Output
13	- - - -	No Connection
14	GND	System Ground
15	INTL 2	**Output:** From Optional Tuner Interlock Switch
16	AIR SW	**Output:** Fan Interlock Signal *
17	FAN (+)	**Input:** Power for Tuner Unit Fan *
18	FAN (-)	**Input:** Power for Tuner Unit Fan *
19	C1 POS	**Output:** C1 Position Voltage
20	- - - -	No Connection
21	- - - -	No Connection
22	- - - -	No Connection
23	DC BIAS	**Output:** DC Bias Detector Voltage
24	M2 (-)	**Input:** C2 Motor Drive (negative side)
25	GND	System Ground

* *These signals are only used on air-cooled units.*

A.3   DIP Switches

The control board inside the Controller unit contains a bank of 12 DIP switches used to set various parameters on the MWH-5-01.

The DIP switch settings are only read upon power-up. It is necessary to remove and reapply power before new settings are used by the Controller.

DIP switch functions break down as follows:

Switch #1-4:

If Switch #12 is OFF these four switches are used to select the RS-422 bus address of the C. The four switches form a 4-bit number as shown below, allowing for sixteen possible addresses (0-15). If a switch is OFF, it is considered a logic 1, and if it is ON, it is considered a logic 0.
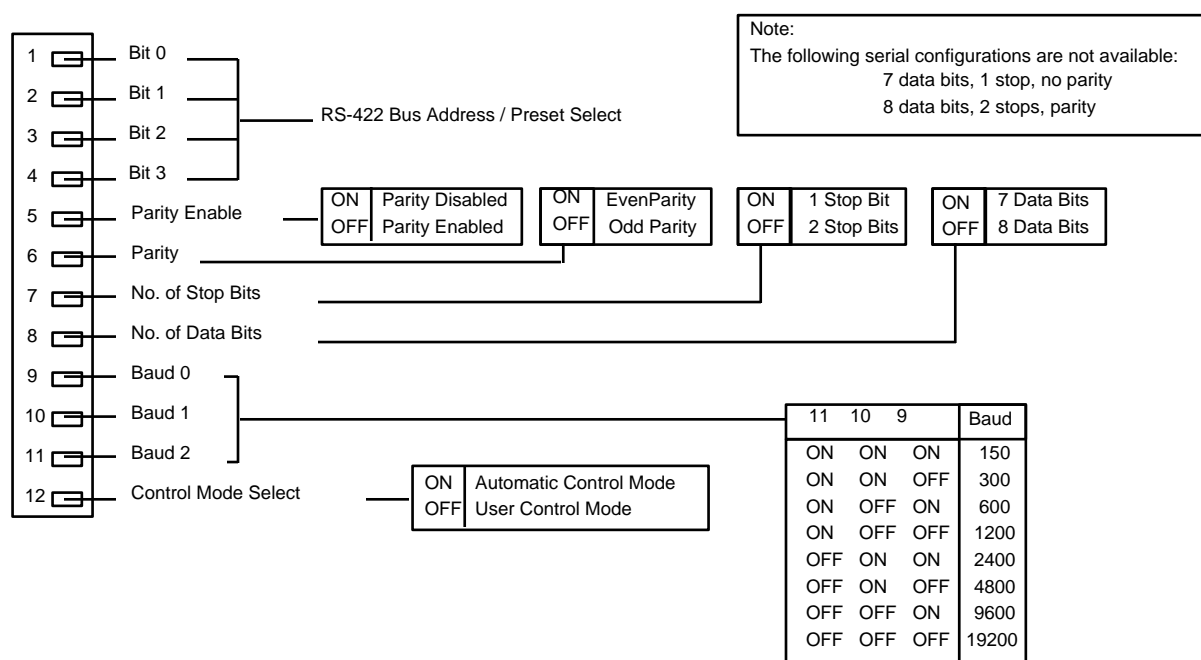
If Switch #12 is ON, these four switches are used to select which preset location is used for Automatic Control mode (see section 3.4).

Switch #5-11:

These switches are used to select the communications parameters for the unit as shown below.

Switch #12:

This switch selects between Automatic Control mode and User Control mode.

A.4   RF Alignment

If the MWH-5-01 can be manually tuned but not auto tuned, the Q ratio may need to be decreased. This is accomplished by changing the output capacitor network C21 through C24 so that the equivalent parallel capacitance is more than the nominal value. Simply replace any, or all of the capacitors in this network with a greater value. Always maintain a minimum of four caps when increasing capacitance to ensure that the current rating of each capacitor is not exceeded.

If you cannot manually tune the system because C1 or C2 tries to go beyond minimum or maximum, use the following procedure:

1.   If capacitor C1 tries to go beyond maximum, add padder capacitors in parallel with C1 in 180pF increments.

2.   If capacitor C1 tries to go beyond minimum, take out one of the padder capacitors.

3.   If capacitor C2 tries to go beyond maximum, either increase the value of inductor L1 by squeezing the turns tighter together or add padder capacitors in parallel with the series output caps at C3a - C3e so that the equivalent parallel capacitance is greater than the nominal value.

4.   If Capacitor C2 tries to go beyond minimum, either decrease the value of inductor L1 by stretching out the turns or change the output capacitor network C3a - C3e so that the equivalent parallel capacitance is less than the nominal value. Always maintain a minimum of four capacitors when decreasing capacitance to ensure that the current rating of each capacitor is not exceeded. If more than one of the four capacitors must be removed, use four smaller, equal-valued capacitors to achieve the total capacitance required.

A.5   Tune Detector Calibration

Note: *A significant design improvement in the MWH-5 over the MW-5D is in the phase-mag sensor. This sensor provides signals which represent the match input impedance phase and magnitude only. The sensor is very insensitive to other disturbances such as load-induced harmonics. Hence, recalibration of the MWH-5 Tune detector should not routinely be required. Since the MWH-5 software includes the calibration routine for the MW-5D Phase-mag sensor, this section is included in this manual for a complete technical description.*

If the MWH-5-01 does not appear to auto tune properly with the attached chamber, the system can be calibrated to optimize its performance with the specific chamber being used.

The following procedure calibrates the phase/mag detectors inside the Tuner unit using an RFC-5MW.

1. With the system up and running and attached to the chamber use the RFC-5MW to set the MWH-5-01 to MAN mode.

2. Set the RF power on the generator to approximately 80% of the maximum power level used.

3. Apply the RF power and manually tune the system for the lowest possible reflected power.

4. Press the SETUP button on the RFC-5MW.

5. Press the MODE button on the RFC-5MW until the

    "Calibrate Phase/Mag" option appears on the display.

6. Press the PSET button to start the calibration process.

7. Once this process is complete, press the MODE button again to exit this option.

8. Press the SETUP button to exit the setup routine. When the RFC-5MW asks if you desire to retain the setup, press the STO button to store the new calibration.